

Docket No.: 200207700-1

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2 TITLE: METHODS AND APPARATUS RELATED TO
3 INFORMATIVE DATA ASSOCIATED WITH
4 GRAPHICAL IMAGE DATA

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(1) TITLE

METHOD AND APPARATUS RELATED TO INFORMATIVE DATA
ASSOCIATED WITH GRAPHICAL IMAGE DATA

(2) CROSS-REFERENCE TO RELATED APPLICATIONS

Not applicable.

(3) STATEMENT REGARDING FEDERALLY SPONSORED
RESEARCH OR DEVELOPMENT

Not applicable.

(4) REFERENCE TO AN APPENDIX

Not applicable.

(5) BACKGROUND

TECHNICAL FIELD

[0001] This disclosure relates generally to data packing, data alignment, data tracking, and data retrieval for informative data printed in association with visible images.

DESCRIPTION OF RELATED ART

[0002] Commercially available still-image digital cameras are now provided with the capability of recording added data, such as audio data, at substantially the same time as the image is made, permitting the photographer to create informative data associated with each image; e.g., subject, time, and place, camera settings, personal notes, and the like.

Such audio data may be played back when viewing the images, either on

1 the camera itself, through a dedicated data retrieval device, or simply
2 through the audio system of a separate viewer, such as a television to which
3 the camera is attached by appropriate cabling. Exemplary systems are
4 described by the Kodak company in European Patent Application no.
5 98204128.7, claiming priority of December 18, 1997, U.S. Ser. No.
6 09/994,000, "Recording audio and electronic images," and European Patent
7 Application no. 98293451.4, claiming priority of October 28, 1997, U.S. Ser.
8 No. 09/959041, "Methods and apparatus for visually identifying an area on
9 a photograph or image where digital data is stored;" both incorporated
10 herein by reference. Kodak's systems prefer non-visible ink when printing
11 data other than that of the image itself.

12 [0003] While digital photographic images are readily printed and
13 shared, the added informative data, such as contemporaneously captured
14 audio data, is much more difficult and cumbersome to share. Talking
15 photograph albums are known in the art, but require inserting each
16 photograph of interest, taken at a prior time, into the album and then
17 recording a message for each in a digital audio recording apparatus built
18 into the album. These devices do not permit substantially simultaneous
19 recording of the image data and the added informative data.

20 [0004] The art of ink-jet technology is relatively well developed.
21 Commercial products such as computer printers, graphics plotters, copiers,
22 and facsimile machines employ ink-jet technology for producing hard copy.

1 The basics of this technology are disclosed, for example, in various articles
2 in the *Hewlett-Packard Journal*, Vol. 36, No. 5 (May 1985), Vol. 39, No. 4
3 (August 1988), Vol. 39, No. 5 (October 1988), Vol. 43, No. 4 (August 1992),
4 Vol. 43, No. 6 (December 1992) and Vol. 45, No.1 (February 1994) editions.
5 Ink-jet devices are also described by W.J. Lloyd and H.T. Taub in *Output*
6 *Hardcopy [sic] Devices*, chapter 13 (Ed. R.C. Durbeck and S. Sherr,
7 Academic Press, San Diego, 1988). Scanning printhead ink-jet printing
8 apparatus are commercially available. The scanning carriage may carry
9 other sensors used for monitoring various parameters and characteristics
10 related to ink-jet printing functions. For example, Steven Walker, in U.S.
11 Pat. No. 6,036,298, issued March 14, 2000, shows a "Monochromatic
12 Optical Sensing System For Inkjet Printing" (referred to hereinafter as
13 "Walker '298"), assigned to the common assignee hereof and incorporated
14 herein by reference in its entirety, including all related continuation,
15 continuation-in-part, and divisional applications.

16 [0005] There is a need for systems and methods for informative data
17 packing, data alignment, data tracking, and data retrieval.

18 (6) BRIEF SUMMARY

19 [0006] The basic aspects of the invention generally provides for
20 methods and apparatus related to informative data accompanying printed
21 visual image data.

22 [0007] One aspect is an image printing method including: receiving

1 image data; receiving informative data associated with said image;
2 generating data representative of at least one printable alignment indicator
3 for said informative data; and during a single pass of a single print medium
4 through a printing zone, printing thereon said image data and said
5 informative data with said alignment indicator proximate thereto.

6 [0008] Another aspect is a graphical print including: an image area;
7 and a data area containing data information associated with said image,
8 wherein said data area includes at least one data block and at least one
9 marker formed substantially concurrently therewith and providing alignment
10 registration indicia for reading said data block from said print wherein said
11 indicia are situated and constructed for calculating alignment of said data
12 relative to a predetermined path of a read sensor traversing said data block.

13 [0009] Another aspect is scanning ink-jet print and read apparatus,
14 having a printing zone, the apparatus including: controlling mechanisms for
15 operating a plurality of functions of said apparatus; and connected to said
16 controlling mechanisms, transport mechanisms for moving a printing
17 medium through said printing zone, adjacent to said printing zone, carriage
18 mechanisms for scanning in a first axis across said medium when
19 transported in a second axis substantially perpendicular to said first axis
20 through the printing zone, connected to said carriage mechanisms, encoding
21 mechanisms for tracking position and velocity of said carriage mechanisms
22 during said scanning, fixedly mounted to said carriage mechanisms,

1 printhead mechanisms for printing images and alphanumeric characters on
2 said medium, fixedly mounted to said carriage mechanisms, sensing
3 mechanisms for reading pixels on said medium, and playback mechanisms
4 for rendering digital audio data printed in predetermined ones of said pixels.

5 [0010] Another aspect is a method of aligning a data set to a data
6 reader, the method including: printing a photographic image on a sheet of
7 paper; concurrently to said printing a photographic image, printing on said
8 sheet of paper as said data set, audio data recorded substantially
9 concurrently with making said photographic image; concurrently to said
10 printing audio data, printing alignment indicia proximate the data set wherein
11 said indicia is at least one predetermined character having a geometric
12 association to said data set such that a positional relationship of said data
13 set to a predetermined path of said data reader is defined thereby; when
14 subsequently reading said audio data, from said indicia, calculating offset,
15 skew, or both, characteristics of said data set to said predetermined path;
16 and compensating for said offset, said skew, or both.

17 [0011] Another aspect is a method for aligning a linear audio data
18 track for a subsequent track scanning read head adapted for reading the
19 track printed proximate a substantially contemporaneously recorded and
20 printed graphical image, the method including: aligning an approximate mid-
21 height point of the read head wherein the read head has span greater than a
22 height dimension of said track with an approximate centerline of said track;

1 dithering said read head while traversing a predetermined length said data
2 track and recording any change in vertical location of top-of-track, bottom-of-
3 track, or both; calculating track skew from said change; and adjusting path-
4 of-scan said read head for said skew for said subsequent track scanning
5 read head during a subsequent reading of said track.

6 [0012] Another aspect is a method for aligning a linear audio data
7 track for a subsequent track scanning, linear array detector adapted for
8 reading the track printed proximate a substantially contemporaneously
9 recorded and printed graphical image, the method including: when the
10 detector has a span less than a height dimension of said track, aligning an
11 approximate mid-height point of said detector to a linear edge of said track,
12 or, when the detector has a span greater than a height dimension of said
13 track, aligning an approximate mid-height point of said detector to a
14 centerline of said track; detecting changes of output characteristics of said
15 detector while scanning said track related to one or both linear edges
16 thereof, and calculating track skew from said changes of output
17 characteristics.

18 [0013] Another aspect is a graphical image print including: an image
19 region having a dot matrix array of colored pixels forming a graphical image;
20 an informative data region, wherein digital code is formed as individual
21 pixels wherein a non-printed pixel is representative of a digital one or zero
22 and a colored pixel is representative of a complementary digital zero or

1 digital one, respectively, and wherein combinations of single pixels in a one-
2 dimensional or two-dimensional array for digitally coded audio information;
3 and at least one informative data region alignment marker for aligning a read
4 head to said data region.

5 [0014] Another aspect is a print and read ink-jet apparatus including:
6 mechanisms for printing digital data including data representative of
7 graphical images and at least one field of digital audio data associated with
8 said graphical images, wherein said digital audio data is printed with
9 alignment indicia proximate thereto; and mechanisms for reading and
10 playing said digital audio data and alignment indicia, wherein said alignment
11 indicia is read prior to or in conjunction with said digital audio data for
12 maintaining reading alignment between said mechanisms for reading and
13 playing and said at least one set of digital audio data.

14 [0015] Another aspect is a photographic imaging system, including a
15 digital camera having an audio recording and playback subsystem; and a
16 printer for printing image data and audio data associated with the images
17 recorded using said camera on a sheet medium, wherein said digital audio
18 data is printed on said medium without interfering with visibility of said image
19 data and with alignment indicia data proximate said audio data for
20 maintaining reading alignment thereof and such that said alignment indicia is
21 readable by said digital camera.

1 [0016] The foregoing summary is not intended to be inclusive of all
2 aspects, objects, advantages and features of the present invention nor
3 should any limitation on the scope of the invention be implied therefrom.
4 This Brief Summary is provided in accordance with the mandate of 37
5 C.F.R. 1.73 and M.P.E.P. 608.01(d) merely to apprise the public, and more
6 especially those interested in the particular art to which the invention relates,
7 of the nature of the invention in order to be of assistance in aiding ready
8 understanding of the patent in future searches.

9 (7) BRIEF DESCRIPTION OF THE DRAWINGS

10 [0017] FIGURE 1 is a depiction of informative data track skew,
11 illustrating a problem in the state of the art.

12 [0018] FIGURE 2 is a schematic depiction an of informative data
13 alignment-realignment process in accordance with a first exemplary
14 embodiment of the present invention.

15 [0019] FIGUREs 3A and 3B are schematic depictions of informative
16 data alignment-realignment processes in accordance with another
17 exemplary embodiment of the present invention.

18 [0020] FIGURE 4 is a schematic depiction of an informative data
19 alignment-realignment process in accordance with a variant of the
20 exemplary embodiment of the present invention as shown in FIGURE 3.

21 [0021] FIGURE 5 is a schematic depiction of an informative data
22 alignment-realignment process in accordance with another exemplary

1 embodiment of the present invention.

2 [0022] FIGURE 6 is a schematic depiction of an informative data
3 alignment-realignment process in accordance with an auxiliary process for
4 pre-estimating a data track centerline, useful in other disclosed exemplary
5 embodiments of the present invention.

6 [0023] FIGURE 7 is a schematic depiction of an informative data
7 alignment-realignment process in accordance with another exemplary
8 embodiment of the present invention.

9 [0024] FIGURE 8 is a schematic depiction of an informative data
10 alignment-realignment process in accordance with another exemplary
11 embodiment of the present invention.

12 [0025] FIGURES 9A and 9B are schematic depictions of informative
13 data alignment-realignment processes in accordance with a variant of the
14 exemplary embodiment of the present invention as shown in FIGURE 8,
15 adapted for single pixel data packing.

16 [0026] FIGURE 10 is a schematic depiction of an informative data
17 alignment-realignment process in accordance with another exemplary
18 embodiment of the present invention.

19 [0027] FIGURE 11 is a generic process flow chart in accordance with
20 the basic aspects of the present invention.

21 [0028] FIGURE 12 is a schematic representation of a scanning ink-jet
22 printing and data retrieval apparatus in accordance with an exemplary

1 embodiment of the present invention and used in accordance with the
2 processes as shown in FIGURES 2, 3A, 3B, 4, 5, 6, 7, 8, 9A, and 9B.

3 [0029] Like reference designations represent like features throughout
4 the drawings. The drawings in this specification should be understood as
5 not being drawn to scale unless specifically annotated as such.

6 (8) DETAILED DESCRIPTION

7 [0030] Ink-jet printing apparatus scanning carriages which carry both
8 ink-jet printheads and associated sensing devices are well-known in the art
9 (see Background section and Walker '298 cited therein). **FIGURE 12** is a
10 schematic representation of a scanning ink-jet printing and data retrieval
11 apparatus in accordance with an exemplary embodiment of the present
12 invention. FIGURE 12 is a schematic drawing illustrating fundamental
13 elements of an ink-jet apparatus 01 which may be employed in accordance
14 with the present invention. A carriage 03 has printheads 04, 05, 06, 07
15 fixedly mounted therein for printing on media 13 (lead edge or trailing edge
16 view) moved by a media transport mechanism 23 through a print zone
17 scanned by the carriage 03 as the printheads fire droplets of ink in a dot-
18 matrix pattern to form images and alphanumeric text or other data patterns.
19 An encoder strip 09 and velocity-position encoding detector mechanism 11
20 is provided for tracking speed and lateral position of the carriage 03 as it
21 bidirectionally scans, represented by double-headed arrow "S," the printing
22 zone and across the print media 13. A sensor 15 having a Read field-of-

1 view 17 is also fixedly mounted to the carriage 03. Real time positioning of
2 the sensor 15 is also performed with the encoder strip 09 and position
3 encoding detector mechanism 11. A programmable application specific
4 integrated circuit ("ASIC"), or microprocessor, based controller 21 provides
5 for functionality and coordination of the apparatus subsystems. Appropriate
6 digital decoding and playback, e.g., audio signal process, electronics 19
7 ("Playback") is incorporated into the pnr apparatus 01. The processes in
8 accordance with the present invention may be implemented in the
9 programming of the apparatus 01, in conjunction with the functional
10 operations of the various subsystems thereof as will become apparent from
11 the following descriptions of exemplary embodiments.

12 [0031] For convenience in describing the present invention, the ink-jet
13 carriage 03 carrying both printheads 04-07 and a reading sensor 15 is
14 referred to hereinafter as a Print-and-Read carriage, or more simply a "PnR
15 carriage." An ink-jet apparatus 01 incorporating the present invention is
16 referred to hereinafter as a Print-and-Read apparatus, or "PnR apparatus."
17 The PnR carriage in accordance with the present invention may carry a
18 specially adapted sensor or, "Read head," device such as described in
19 assignee's Walker '298 patent, or it may use adapted commercially available
20 discrete sensors. Typical, adaptable sensors and detectors include for
21 example, photodetector mechanisms like the Perkin Elmer model FFD-100
22 photodiode, model VTT1015 phototransistor, or line-scan imagers such as

1 their P-series linear photodiode array imagers and their L-series CMOS
2 photodiode arrays. In accordance with the present invention, additional
3 functionality are incorporated in the ink-jet class of printers and digital
4 cameras so that they can further operate as informative data recovery, or
5 retrieval, systems for digitized informative data added onto a printed sheet
6 bearing associated, printed, digital data forming graphical images.

7 [0032] Technology for making digital images and storing image data
8 with accompanying additional informative data is known in the art, e.g., a
9 digital camera; no further description is essential to an understanding of the
10 present invention. Data retrieval for showing the stored image and playback
11 of added informative data, such as a contemporaneously stored audio track,
12 via a speaker, is also known in the art, e.g., connecting the camera to an
13 audio-video apparatus; no further description is essential to an
14 understanding of the present invention.

15 [0033] For the purpose of describing exemplary embodiments of the
16 present invention, the visual image data printed by the PnR apparatus is
17 said to be a "photograph;" no limitation on the scope of the invention is
18 intended by the inventors, nor should any be implied therefrom (see also,
19 Background section hereinabove). As the PnR carriage traverses across
20 the width of the photographic paper, one or more blocks of informative data
21 may sequentially printed or, at a later time, retrieved, also referred to as
22 "playback." The physical region where one linear segment of readable data

1 is recorded will be called a "data track."

2 [0034] The PnR carriage is known to return to a starting position, e.g.,
3 a carriage stop, edge of media or the like, dependent upon whether the
4 printing is unidirectional or bidirectional, getting ready for the next line of
5 data. The paper feed mechanism will advance the photograph to the next
6 line of data. Any transverse return motion for unidirectional printing may
7 occur coincidentally or non-coincidentally with respect to the photographic
8 paper motion. The data track(s) may be printed visibly, such as in a non-
9 image border region of the print medium, or invisibly in a known manner so
10 as not to interfere with the aesthetics of the printed image (see e.g., Kodak
11 patent applications describe in the Background section hereinabove).

12 Additionally, given an appropriate printhead arrangement or a media
13 transport which allows duplexing of media sheets, such data track(s) may be
14 printed on the reverse side of the sheet from the image side. To get a
15 higher data recording density, both the width of data tracks and the track-to-
16 track center spacing ("track pitch density") should be kept as small as
17 possible. Narrow tracks at high track pitch density will make data recovery
18 more difficult without some type of tracking mechanism. Alignment lines or
19 marks described in accordance with the present invention will keep a Read
20 head, or sensor, on-track during the retrieval process. The Read head may
21 have a very small area of coverage, "field-of-view," relative to the widths of
22 the data track and the data bits. Thus, for some embodiments it is

1 contemplated that each printed informative data bit may in fact be only
2 single picture element ("pixel"), namely, having a one pixel track height; each
3 pixel can be paper white - namely, non-printed - or colored, and therefore
4 represent a digital one or digital zero data bit. It can be recognized as an
5 advantage of the present invention that single pixel data packing is made
6 possible. Track pitch density may be reduced accordingly wherein, if the
7 point detector has a field-of-view of less than one picture element ("pixel"),
8 even adjacent tracks may be separate data tracks. Note that as another
9 advantage of the present invention, invisible inks and the like need not
10 necessarily be employed as current ink-jet printing technology can present
11 ink dot density in excess of 2000 dots-per-inch, i.e., invisible to the naked
12 eye even if a single pixel line of alternating black-and-white dots are printed
13 as informative digital data. Alternatively, a data track height incorporating
14 several pixels or superpixel clusters may be employed.

15 [0035] While it is recognized that the informative data on the
16 photographic print may have been printed on a different PnR apparatus than
17 the one used to recover it, even if using the same PnR apparatus for
18 playback of recorded audio data tracks, it would not be expected that at a
19 high track pitch density such as contemplated by the present invention that
20 the PnR carriage would accurately retrace the data that was laid on the
21 photograph paper previously once it had been already ejected from the
22 printer. In other words, once the photograph is disengaged from the paper

1 feed mechanism, misalignment is likely to happen when the photograph is
2 fed back even into the same printer for an audio playback. **FIGURE 1** is a
3 depiction of informative data track skew, illustrating a problem in the state of
4 the art. It can be readily recognized that for an accurate reading of a data
5 track 101, 103, the reader must preferably be straddling the centerline C- -C
6 of the tracks. Also, FIGURE 1 shows the possibility of a skew 100 between
7 the centerline C- -C of each data field 101, 103 printed on the photographic
8 media 102 and the locus of the new path 105 of the PnR carriage projected
9 on the photographic media.

10 [0036] To determine the amount of misalignment so it can be
11 corrected before or during data recovery, in accordance with exemplary
12 embodiments of the present invention one or more of alignment indicators,
13 or indicia, are printed on the photograph in conjunction with the informative
14 data at the same time each data track is being printed. These alignment
15 indicators will give information and act as tools so as to enable the PnR
16 carriage to adjust to offset the skew during informative data recovery.

17 [0037] **FIGURE 2** is a schematic depiction an of informative data
18 alignment-realignment process in accordance with a first exemplary
19 embodiment of the present invention. In FIGURE 2, let a schematic Data
20 Region 201 represent a printed informative data track, or plurality of tracks,
21 on a photograph or in a border margin of the photographic paper. Arrows
22 labeled A and B represent a subsequent insertion, PnR carriage motion,

1 while arrow P represents paper feed directionality. Alignment indicators
2 203, 204, 205, 207 have been printed concurrently and proximate to the
3 Data Region 201. In this embodiment, vertical alignment line, "VAL"
4 indicators 203, 205, 207, 209 are employed, which may have varying inter-
5 line spacing, varying thicknesses, or both, as shown.

6 [0038] During informative data reading, while the PnR carriage is at or
7 near the top of the vertical alignment lines and traversing with PnR Carriage
8 Motion A, distance d_1 is determined as the sensor on the carriage moves
9 across the page in one or more passes, where d_1 may be for instance the
10 distance in the axis of carriage motion from the edge of the paper, or from
11 the carriage stop, or from any fixed, known, carriage position determined
12 from the encoder subsystem (see FIGURE 12 and related description,
13 hereinabove) to a predetermined one of the VAL indicators, e.g., line 203.
14 Depending on the degree of accuracy desired and which may be related to
15 the track pitch density, several determinations may be desirable, e.g., d_1
16 from the paper edge to VAL 203, d_1 from the paper edge to VAL 205, et seq.
17 Similarly, after an appropriate paper advance and while scanning PnR
18 Carriage Motion B at or near the bottom end of the VAL indicators 203, 205,
19 207, 209, distance(s) d_2 is measured. The measured difference value(s), d_1
20 $-d_2$, is a factor suitable for calculating the degree of skew in the paper feed
21 direction, P. The skew in the paper feed direction in the measurement of
22 the skew angle Θ is then:

$$\Theta = \tan^{-1} (d_2 - d_1 / D_p), \quad (\text{Equation 1})$$

where D_p is the separation between the PnR carriage motions A, B in the paper feed directions P as shown in FIGURE 2. In most cases, the skew in the PnR carriage direction is close to the skew in the paper feed direction since, by design, the paper feed direction is generally orthogonal to that of the PnR carriage motion. Manufacturing tolerance may cause slight deviations from design specifications. Where more than one top of VAL distance, d_1 , and bottom of VAL distance, d_2 , is determined, an average, median, or other value may be used for skew determination. Once the skew is determined, a correction factor is calculated in a known manner and coordinated to the PnR carriage scan drive and paper feed as it moves across the page to retrieve the data on each data track of region 201. In other words, if skew is significant enough such that a specific informative data track will be lost to the field-of-view of the sensor as it is scanned across the Data Region 201, compensation is applied to adjust the paper position accordingly as the data is read, namely, reading the data and playing the audio in a seamless manner.

[0039] It may be recognized that nominally the PnR carriage motion A, B (x-axis) is perpendicular to the direction of the paper feed P (y-axis). If the actual angle between the direction of the paper feed and the PnR carriage on the printer that first produce the photograph is almost the same as that on the printer that performs data recovery, the above correction

1 might be sufficient to minimize the PnR carriage skew in retrieving the
2 informative data. If the skew correction is not adequate using this
3 embodiment of VAL indicators method because the two angles differ too
4 much, the following methods will overcome this further problem.

5 [0040] **FIGURES 3A and 3B** are schematic depictions of informative
6 data alignment-realignment processes in accordance with another
7 exemplary embodiment of the present invention. A linear informative data
8 track 301 is shown as having a centerline C- -C. As in FIGURE 2, carriage
9 motion is represented by arrow A; print media motion is represented by
10 arrow P. Concomitantly with the recording of the informative data track 301,
11 at least one Track Alignment Mark ("TAM") indicator 303 is printed. The
12 TAM indicator 303 is a predetermined relative horizontal design, here the
13 alphabetic character letter "N," printed such that the centerline C- -C is also
14 through the centerline of the design and having a feature, here the slash
15 piece of the "N," which when read across various horizontal planes thereof
16 provides a tool for measurement representative of offset from the centerline
17 in the current respective relative vertical.

18 [0041] Looking to FIGURE 3B, upon reinsertion and feed of the paper
19 through a PnR apparatus for informative data playback, the measurements
20 of the read design in the current orientation to the read sensor, that is, the
21 difference between S1 and S2, is an indication of how much the read sensor
22 is off from the centerline C- -C. In other words, given the known dimensions

1 of the design, by using the sensor to measure S1 and S2 during a current
2 carriage motion "A" scan, the vertical displacement of the read sensor from
3 the centerline C- -C of the data track is also measured. Using this
4 indication, paper feed can be advanced or reversed to achieve an optimum
5 data reading path straddling the centerline such that dithering of the paper
6 during playback is not required. A TAM indicator 303 may be placed at the
7 beginning, the end, or both ends of the data track 301. Note that by placing
8 a TAM 303 at both ends of the data track 301, a pair of S1, S2
9 measurements - namely (S1-S2) at the beginning-of-track, and (S1-S2) at
10 the end-of-track - can also be used to calculate skew, if any, of the data
11 track between centerline C- -C and new path of carriage motion "A" versus
12 the printing carriage path. If it is determined that skew is such that the field-
13 of-view of the sensor will leave a given data track during one-pass scanning,
14 dithering of the paper can again be employed.

15 [0042] **FIGURE 4** is a schematic depiction of an informative data
16 alignment-realignment process in accordance with a variant of the
17 exemplary embodiment of the present invention as shown in FIGURE 3. In
18 order to achieve better track servoing performance, more track misalignment
19 information may be generated and acquired for each data track 401. A
20 series of S1, S2 measurements (see FIGURE 3B) is obtained for each data
21 track 401 by embedded TAM ("ETAM") indicators 403ab, 403bc, et seq.,
22 among recorded segments 401, 401a, 401b, also referred to as "data fields,"

1 of the informative data track 401. These measurements can be pre-
2 analyzed by doing a Read signal scan along a nominal centerline C- -C (see
3 also, e.g., FIGURE 6 described hereinbelow), or can provide closed-loop on-
4 going, or real-time, error signaling as the data track 401 is being read. In
5 other words, there are a plurality of alignment markers $403_{x,y}$ printed at
6 predetermined positions of the data track 401, interspersed with individual
7 data fields $401_{x,y}$ thereof, such that a current offset-from-centerline value can
8 be determined at each of said markers, thus providing a factor for also
9 calculating skew value for feedback to active track servoing using the paper
10 feed mechanism as soon as two or more ETAM indicators have been read
11 and analyzed.

12 [0043] Note that both VAL indicators 203, 205, 207, 209, FIGURE 2,
13 and TAM indicators 303, $403_{a,b,c...y}$ may be used simultaneously and
14 interchangeably. For example, horizontally printed VAL indicators can be
15 employed for track misalignment measurements and correction factor
16 calculations. The letter "Z" for example may be used as a TAM or ETAM
17 marker for vertical offset and skew detection and correction. Combinations
18 of the two may be employed.

19 [0044] **FIGURE 5** is a schematic depiction of an informative data
20 alignment-realignment process in accordance with another exemplary
21 embodiment of the present invention, a data track envelop detection
22 process. In the data track envelop detection method, the top and bottom

1 edges of a data track 501 are used as the alignment indicators to determine
2 the track skew relative to the motion of the PnR carriage. In an initial
3 alignment pass of the carriage along the nominal centerline C- -C (see also,
4 e.g., FIGURE 6 described hereinbelow), the sensor is dithered substantially
5 orthogonally with respect to the data track 501, represented by double-
6 headed arrow "D-D," so as to locate the envelop, or extent, of the data track
7 along the paper path direction. For example, to dither the Read head, or
8 sensor, orthogonally with respect to the motion of the PnR carriage during
9 the alignment pass, the photographic paper 102 would feed back and forth
10 under the control of the paper feed mechanism - again illustrated by arrow
11 P. The vertical displacement of the edges of the data track at two or more
12 places separated by some horizontal distance, "h," along its length would
13 determine the amount of track skew. It will be recognized by those skilled in
14 the art that in this and the other described embodiments herein, multiple
15 alignment passes may be employed; it may be advantageous to use multiple
16 passes in order to reduce measurement errors.

17 [0045] **FIGURE 6** is a schematic depiction of an informative data
18 alignment-realignment process in accordance with an auxiliary process for
19 pre-estimating a data track centerline, useful in other disclosed exemplary
20 embodiments of the present invention. As nominal centerline C- -C
21 knowledge is important to several of the methodologies described herein,
22 associated with each data track there could be printed a Track Center Mark

1 ("TCM") indicator 603 which is laid down proximately to the start of each
2 data track 601 (unidirectional or bidirectional) at the time the informative
3 data is being printed on the photographic print media. The TCM indicator
4 603 will facilitate a PnR carriage search for and location of the centerline C-
5 -C of each data track 601 in the first stage of a data retrieval process. The
6 field-of-view of the Reading device is positioned to straddle the TCM
7 indicator 603 for the nominal centerline C- -C of the data track 601 before
8 attempting to read the informative data contained therein. Note that if the
9 maximum skew is estimable, and the track heights and track densities
10 tailored accordingly, and using a sensor with an appropriate field of view,
11 using the TCM indicator 603 as the alignment mark may be sufficient to
12 allow playback without any further requirement for active skew
13 compensation.

14 [0046] **FIGURE 7** is a schematic depiction of an informative data
15 alignment-realignment process in accordance with another exemplary
16 embodiment of the present invention. In this exemplary embodiment of the
17 present invention, a linear array detector 703 is employed as a Read head.
18 The linear array detector 703 is made up of a multiplicity of "point" detectors
19 702 arranged in a linear, or one-dimensional, array. Each point detector
20 performs independently, producing a read-back signal according to the
21 imaging area each detector covers. In the implementation of FIGURE 7, the
22 linear array detector 703 is wider than the width of the data track 701 so it

1 will nominally straddle the width of the entire data track; i.e., the paper
2 transport can dither the paper until the detector 703 is in alignment shown at
3 position 705. As depicted in FIGURE 7, by comparing detector 703 output
4 at position 705 and position 705a, the data pattern the linear array detector
5 703 reads will vary if the PnR carriage is not moving parallel to the data
6 track 701 centerline C- -C. Since the linear array detector 703 is wider than
7 the data track 701, the amount of skew can be determined by analyzing the
8 signals from each individual detector 702 in the array. With a full width
9 linear array detector, it is also possible to incorporate 2-D data coding,
10 discussed hereinbelow. As with FIGURE 6, alternatively to using the data
11 track itself, separate alignment indicators could be generated and printed for
12 designating a top-of-track alignment mark 707 and bottom-of-track
13 alignment mark 709, positioned at one end or at each end of the data track
14 701, wherein these indicators become the two skew check positions.

15 [0047] **FIGURE 8** is a schematic depiction of an informative data
16 alignment-realignment process in accordance with another exemplary
17 embodiment of the present invention. In this further exemplary embodiment
18 of the present invention, similar to that in FIGURE 7, the embodiment has a
19 linear array detector 803 with a span less than the data track 801 height.
20 When the linear array detector 803 is smaller than the data track 801 height,
21 in order to determine the amount of skew, first one edge - top or bottom - of
22 the data track is found by dithering at a first position 805 along the length of

1 the track 801. Then, the linear array detector 803 is positioned over that
2 edge and a pass in the scan axis, S, over the data track 801 is made.
3 Provided the data track skew is not too much in relation to the width of the
4 array, a single pass will be enough to capture the degree of the skew; e.g,
5 as shown, the output of the top element 802 of the narrow linear array 803
6 by the time it has reached position 805a will have changed due to the
7 relative vertical shift with respect to the data track centerline C- -C. If the
8 skew of the initially captured edge is more than the size of the array, the
9 skew could still be measured; the paper could be advanced or reversed
10 along axis P by a known distance while the detector is partway along the
11 data track 801.

12 [0048] **FIGURES 9A and 9B** are schematic depictions of informative
13 data alignment-realignment processes in accordance with a variant of the
14 exemplary embodiment of the present invention as shown in FIGURE 8,
15 adapted for single pixel data packing. This illustrates a similar embodiment
16 to FIGUREs 7 and 8, but implemented using slit detectors 903a, 903b. The
17 fundamental methodology is identical to FIGURE 8. It will be recognized by
18 those skilled in the art that this implementation is conducive to use of a
19 single pixel height informative data track 901. Each pixel 905 comprises a
20 digital data bit by being printed with a color dot of ink or non-printed, paper
21 white.

22 [0049] **FIGURE 10** is a schematic depiction of an informative data

1 alignment-realignment process in accordance with another exemplary
2 embodiment of the present invention. A digital camera (not shown) itself
3 can be made to function as an informative data recovery device. When the
4 informative data region is rendered on the print media in the visible
5 spectrum, the user can focus the camera on the data region, frame it, and
6 take an image of the region. In one single exposure, a large amount of data
7 is captured substantially instantaneously, allowing a large area block data
8 recovery method. The captured image in the camera, viz, a digital photo of
9 the data block itself, is next converted in a known manner to digital data,
10 which is decoded to produce the audio signal from the built-in loudspeaker
11 in the camera.

12 [0050] Note that if the data region is outside the visible spectrum, an
13 illumination source (e.g., infrared, ultraviolet or the like) provided in the
14 camera must be turned on to aid the data capture process. The illumination
15 source would render the data region visible to the image sensor in the
16 camera, which would in turn display the recovered image on its liquid crystal
17 display ("LCD") screen so the user could visualize the prerecorded but
18 otherwise invisible data region.

19 [0051] In order to cover a larger data region to read in more data, and
20 thus allow a longer audio data file, multiple exposures might be necessary.
21 This is because the camera has a finite spatial resolution which must be
22 overcome. The process starts with the user taking successive, overlapping

1 images of the entire data region a section at a time. Once the entire data region
2 has been captured piecemeal, data stitching software in the camera would piece
3 the images together forming a much larger data file. To help the user making
4 overlapping exposures, the data sections are delineated by some type of alignment
5 indicators 1001, "Delineation Markers," which are again as in previous
6 embodiments laid down at the same time when the photograph is being printed.
7 Note that alternatively, instead of just Markers at the corners, the data sections
8 may be enclosed by delineation borders in which data section information, such as
9 coordinate identification, may also be encoded and embedded, "Encoded
10 Delineation Markers." In other words, the markers themselves may have
11 functional alignment data or information embedded therein. Such camera-readable
12 section identification may help the data retrieval process. For example, the user
13 does not need to retrieve the data sections in a particular sequential order, though
14 that is a logical task. If for some reason any particular section is not correctly
15 captured, e.g., out-of-focus, the camera could inform the user such data section
16 needs to be re-captured. Besides the section coordinates, information about the
17 data organization, e.g., array partitioning information, may be and preferably is
18 included in the delineation border. "Coordinate Identifiers," 1003, e.g., A, B, 1, 2,
19 matrix designations, on the periphery of the macro data region made up of the
20 annotated "Data Sections" would further help the user to keep track of and identify
21 what data section to image and in what logical order. It

1 is also possible to effectively accomplish the same goal of large area block
2 data recovery by a slight variant. Instead of requiring the user to take one or
3 more exposures of the data regions, the camera could be designed in ways
4 that a series of shots will be automatically taken as the camera is moving
5 over the data regions while the shutter is being depressed. In other words,
6 the images are being captured in a motor drive, or stroboscopic, mode.

7 [0052] In accordance with FIGURE 10, the data retrieval process in
8 this scheme is a block access method, as opposed to a sequential access
9 method used in a conventional scanning scheme such as described in
10 accordance with FIGURES 1-9B. This large area block data recovery
11 scheme fully takes advantage of the camera's field of view which is much
12 larger than that of a typical read-back head, or other sensor, in a
13 conventional scanner. Block access is in essence a parallel operation, and
14 thus offers a much higher data capture rate. From a user's point of view,
15 there are several important advantages in the large area block data recovery
16 scheme described here. The most obvious and highly desirable advantage
17 is the convenience this method and extra functionality incorporated into the
18 camera provides since a dedicated data retrieval and playback device is not
19 needed. The procedure to retrieve the data is also very straightforward and
20 simple. Inherent in the block access method, it could acquire the data much
21 faster. For example, for small data regions all it takes is a single aim-and-
22 shoot operation. Low cost of implementation is another important benefit.

1 [0053] The fact that the camera is imaging an area at an instant in
2 time, as opposed to sequentially retrieving data a line at a time, could be
3 exploited advantageously in encoding the data. One-dimensional coding
4 goes hand-in-hand with the conventional scanning scheme because it is
5 very difficult and not cost-effective to spatially synchronize several data
6 scans taken over some time interval. On the other hand, in imaging an area
7 the spatial relationship between every pixel and its neighbors is precisely
8 preserved within the limit of the resolution of the camera's optics and the
9 image sensor. The pixels could be grouped in units of a predetermined two
10 dimensional ("2-D") array in which the data is eventually encoded and
11 decoded. The advantages of a 2-D coding scheme are that it would result in
12 a better SNR, higher data coding density, or both, in addition to the ability to
13 produce a more robust code that is less prone to error. In such prints,
14 because of the larger amount of room that may be taken up by extensive
15 data, it may be preferable to print the informative data, Delineation markers
16 1001, and Coordinate Identifiers 1003 invisibly and to provide the camera
17 with a mechanism for illuminating as described hereinbefore.

18 [0054] **FIGURE 11** is a process flow chart depicting a generic
19 methodology in accordance with the present invention. In accordance with
20 the present invention, the informative data is printed with alignment
21 indicators, 1101. On the same media, the graphics data is printed in a
22 known manner, 1103. The digital data which contains information and print

1 graphics data may be printed in any order. The essential step is the
2 concomitant printing of the informative data tracks and proximate alignment
3 indicators. The printed sheet is ejected, 1105, from the PnR apparatus (see
4 FIGURE 12).

5 [0055] At some later time, whenever it is the user's desire to playback
6 the informative data, the media is inserted, 1107, into the same, or a
7 compatible, PnR apparatus. In accordance with known manner controls and
8 programming of such apparatus, a "Playback Mode" is initiated, 1109.

9 [0056] Optionally (indicated by phantom line connection), if one of the
10 embodiments requiring a centerline approximation is required to pre-position
11 the informative data detector (see FIGURE 1, element 15, and FIGURE 6),
12 or if a TCM 603 is employed as a primary alignment indicator for the data
13 track, 1111, YES-path, a search for such a first TCM 603 is employed, 1113.
14 Next, an alignment indicator is sensed, 1115. Once acquired, the skew
15 measurements described hereinbefore can be respectively determined and
16 alignment compensation calculated, 1117.

17 [0057] Once appropriate compensation is programed into the PnR
18 apparatus, playback is commenced, 1119. The playback should be
19 seamless as any offset or skew of the informative data relative to the read
20 head will be compensated.

21 [0058] It should also be recognized that since the data is coded
22 digitally, it is possible to multiplex stereophonic signals into a single channel

1 for higher fidelity, multichannel separation playback.

2 [0059] In general, certain options are preferred. Whenever possible,
3 track alignment should be applied to every track as it is being read. The
4 initial determination may be off by a certain amount by the time some
5 distance from the initial tracks is achieved. As each track is scanned, track
6 misalignment information should be collected and applied to the following
7 scans. Moreover, it will be recognized that scanning and capturing all the
8 data tracks, or at least filling the available buffer(s), before playback of audio
9 is advantageous for a continuous, clean sound reproduction.

10 [0060] It should be noted that data retrieval may occur in a bi-
11 directional process. Data format information may be included in a header
12 field at the beginning of the data region, containing any pertinent information
13 other than the audio data itself, such as date/time created, name of creator,
14 whether the data is coded as stereophonic or monophonic, whether the data
15 is bi-directional or uni-directional, data rate, length of the recording in time,
16 length of the data in bytes, and the like.

17 [0061] In a variety of embodiments and implementations, the basic
18 aspects of the present invention relate to a method and apparatus for data
19 packing, including single pixel data bit forms, and playback tracking of
20 informative data associated with graphics images. To maximize the signal-
21 to-noise ratio (SNR) during data recovery, and hence minimize the Read
22 error rate, the Read sensor is kept on-center of each data track throughout

1 the reading process. During the data recovery process, a Print-and-Read
2 ink-jet embodiment carriage mechanism in conjunction with the paper feed
3 mechanism keeps the Read sensor on track center since the misalignment
4 information has already been determined beforehand or in real time for
5 active track servoing.

6 [0062] The foregoing Detailed Description of exemplary and preferred
7 embodiments is presented for purposes of illustration and disclosure in
8 accordance with the requirements of the law. It is not intended to be
9 exhaustive nor to limit the invention to the precise form(s) described, but
10 only to enable others skilled in the art to understand how the invention may
11 be suited for a particular use or implementation. The possibility of
12 modifications and variations will be apparent to practitioners skilled in the
13 art. No limitation is intended by the description of exemplary embodiments
14 which may have included tolerances, feature dimensions, specific operating
15 conditions, engineering specifications, or the like, and which may vary
16 between implementations or with changes to the state of the art, and no
17 limitation should be implied therefrom. It will be recognized by those skilled
18 in the art that this technology may also be employed in other graphics
19 computing, e.g., digital art images wherein the computer artist similarly
20 records associated non-visual information while creating a particular image.
21 Applicant has made this disclosure with respect to the current state of the
22 art, but also contemplates advancements during the term of the patent, and

1 that adaptations in the future may take into consideration those
2 advancements, in other word adaptations in accordance with the then
3 current state of the art. It is intended that the scope of the invention be
4 defined by the Claims as written and equivalents as applicable. Reference
5 to a claim element in the singular is not intended to mean "one and only
6 one" unless explicitly so stated. Moreover, no element, component, nor
7 method or process step in this disclosure is intended to be dedicated to the
8 public regardless of whether the element, component, or step is explicitly
9 recited in the Claims. No claim element herein is to be construed under the
10 provisions of 35 U.S.C. Sec. 112, sixth paragraph, unless the element is
11 expressly recited using the phrase "means for. . ." and no method or process
12 step herein is to be construed under those provisions unless the step, or
13 steps, are expressly recited using the phrase "comprising the step(s) of. . ."
14 What is claimed is: